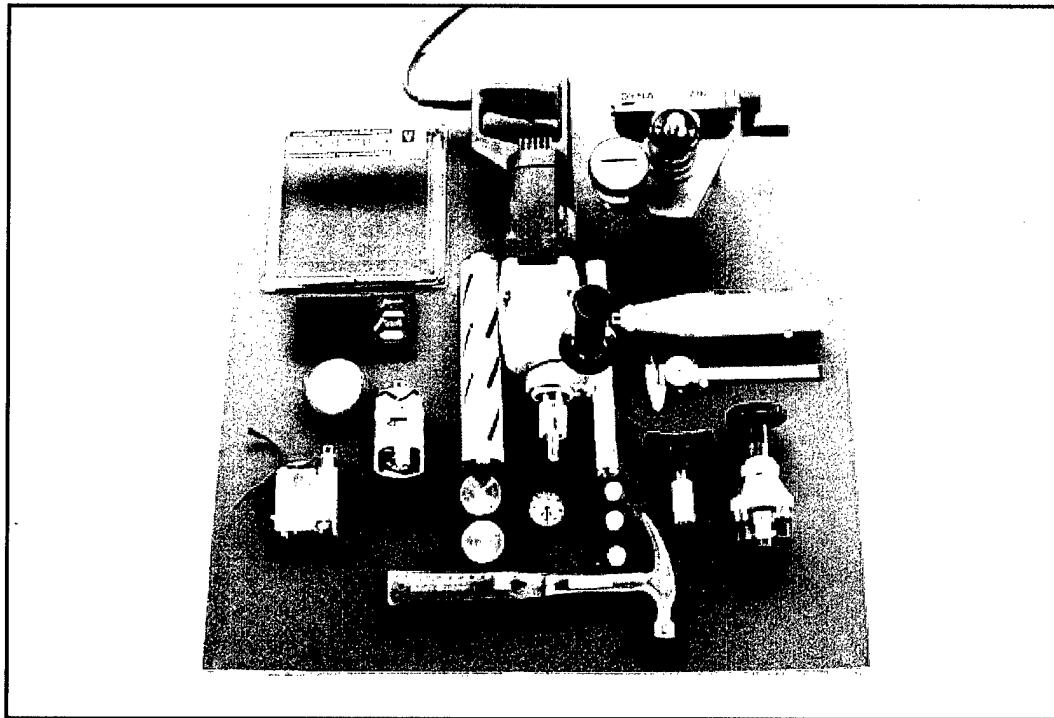




NAVAL FACILITIES ENGINEERING SERVICE CENTER
Port Hueneme, California 93043-4370

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**SEQUENTIAL APPROACH TO A
CONCRETE FLOOR
CONDITION ASSESSMENT**



by
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March 2000

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<p>This report presents a sequential approach to assessing the condition of concrete floors. The condition assessment is to be performed prior to specifying either an initial coating system or an overcoat to an existing coating system. The condition assessment is designed to identify problem floors and eliminate premature coating failures resulting from the following practices: (a) overcoating unsound coating systems, (b) coating concrete with low surface strength, (c) coating concrete with high levels of surface contamination (oils, fuels, fats, waxes, etc.), and (d) coating concrete with a high rate of moisture vapor emission. The condition assessment consists of eight tasks: (1) identify concrete surface texture, (2) identify chemicals and exposures, (3) identify service conditions, (4) measure floor dimension, cracks, joints, and specific defects, (5) determine rate of moisture vapor emission, (6) determine concrete surface strength, (7) determine depth of surface contamination, and (8) determine adhesion of existing coatings. Results from the condition assessment are to be used in specifying appropriate concrete repairs, determining a suitable level of surface preparation, and selecting a proper coating system.</p>			
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EXECUTIVE SUMMARY

This report presents a sequential approach to assessing the condition of concrete floors. The condition assessment is to be performed prior to specifying either an initial coating system or an overcoat to an existing coating system. The condition assessment is designed to identify problem floors and eliminate premature coating failures resulting from the following practices: A) Overcoating unsound coating systems, B) Coating concrete with low surface strength, C) Coating concrete with high levels of surface contamination (oils, fuels, fats, waxes, etc.), and D) Coating concrete with a high rate of moisture vapor emission.

The condition assessment consists of the below eight tasks:

- Identify concrete surface texture.
- Identify chemicals and exposures.
- Identify service conditions.
- Measure floor dimension, cracks, joints, and specific defects.
- Determine rate of moisture vapor emission.
- Determine concrete surface strength.
- Determine depth of surface contamination.
- Determine adhesion of existing coatings.

Results from the condition assessment are to be used in specifying appropriate concrete repairs, determining a suitable level of surface preparation, and selecting a proper coating system.

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INTRODUCTION

This report presents a sequential approach to assessing the condition of concrete floors. The condition assessment is to be performed prior to specifying either an initial coating system or an overcoat to an existing coating system. Results from the condition assessment are to be used in specifying appropriate concrete repairs, determining a suitable level of surface preparation, and selecting a proper coating system. The condition assessment is designed to identify problem floors and eliminate premature coating failures resulting from the following practices: A) Overcoating unsound coating systems, B) Coating concrete with low surface strength, C) Coating concrete with high levels of surface contamination (oils, fuels, fats, waxes, etc.), and D) Coating concrete with a high rate of moisture vapor emission.

The condition assessment consists of eight detailed tasks: 1) Identify concrete surface texture, 2) Identify chemicals and exposures, 3) Identify service conditions, 4) Measure floor dimension, cracks, joints, and specific defects, 5) Determine rate of moisture vapor emission, 6) Determine concrete surface strength, 7) Determine depth of surface contamination, and 8) Determine adhesion of existing coatings. Furthermore, this report contains sources for literature on concrete repair, surface preparation and coatings, and includes a brief discussion on coating selection and customer expectations.

In the below sections, a thin film system shall consist of a coating system \leq 20 mils (1 mil = 0.001") whereas a thick film system shall consist of an aggregate filled coating system \geq 180 mils.

IDENTIFY CONCRETE SURFACE TEXTURE

If a thin film system with high aesthetics is desired, the concrete's surface should display a "Smooth" surface texture (Fig. 1) and not a "Coarse" surface texture (Fig. 2 – 3). When a thin film system is applied to coarse concrete, the coating system may reflect the concrete's texture and decrease aesthetics. A thick film system can be applied to either "Smooth" or "Coarse" concrete. However, concrete that is extremely coarse due to poor workmanship may require additional resurfacing (Fig. 4).

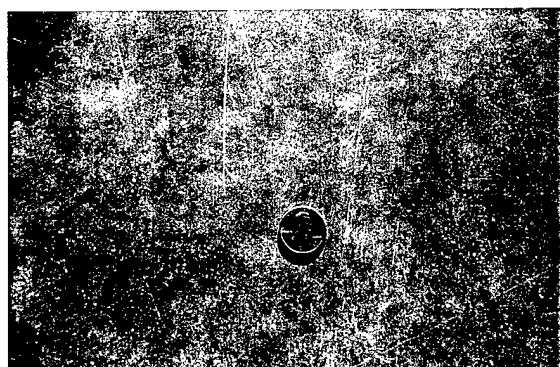


Fig. 1 - "Smooth" surface texture: Steel trowel finish.

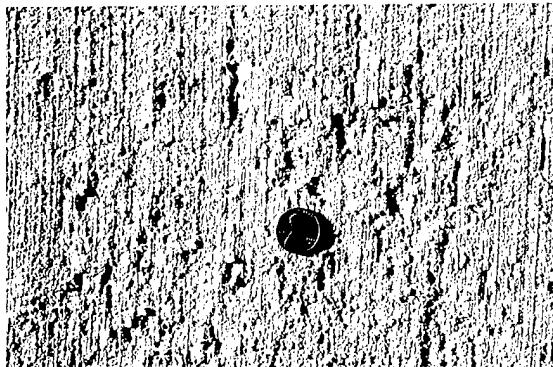


Fig. 2 - "Coarse" surface texture: Wood float finish.

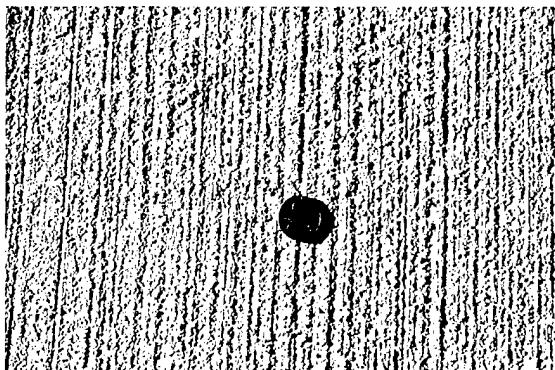


Fig. 3 - "Coarse" surface texture: Broom finish.

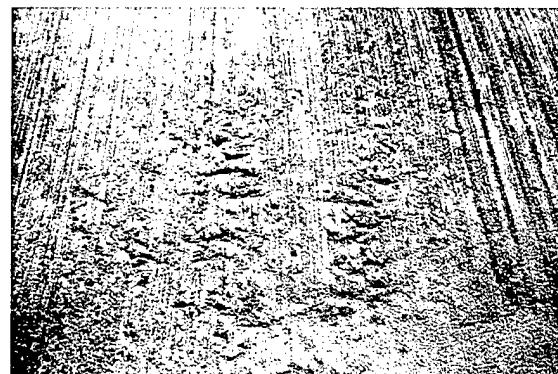


Fig. 4 – Poor surface finishing.

IDENTIFY CHEMICALS AND EXPOSURE

If floor surfaces are to be exposed to chemicals (liquids, gases, solids) from spills, equipment and storage, identify and record each chemical to be used within the flooring space. This task assists in selecting floor coatings that are chemically resistant to the anticipated chemicals and exposure conditions. Chemicals from the following groups should be documented by name and concentration: A) Acids (including batteries), B) Bases (caustics), C) Organic solvents, D) Chlorinated solvents, E) Fuels, F) Oils (fats, waxes), G) Degreasers, H) Detergents (including cleaning solutions), I) Military specification solutions, J) Specialty chemicals, K) Plating baths, L) Liquid gases, M) Water-based solutions (including hot water and water spills), N) Munitions, O) Flammable liquids, P) Explosive gases (not from co-workers), Q) Beverages, and R) Human and animal fluids. The anticipated chemical exposure per group should be identified as Continuous Exposure (CE), Daily Spills (DS), Occasional Spills (OS), or Storage (S).

IDENTIFY SERVICE CONDITIONS

To facilitate the selection of an appropriate coating system, identify and record the floor's intended service conditions. Common service conditions are as follows: A) Forklift traffic (heavy/light), B) Foot traffic (heavy/light), C) Vehicular traffic, D) Wheel traffic (steel, rubber, inflated), E) Compressive loads, F) Impact loads, G) Thermal loads (elevated or cool exposure), H) Thermal cycling (freeze/thaw), I) Thermal shock, J) Partial sunlight exposure (aircraft hangars), K) Chronic dampness or wet conditions (kitchens, showers), L) Sanitized (hospitals), M) Electrostatic dissipative or conductive (munitions, electronic equipment, operating rooms), N) Heavy cleaning (kennels), O) Vibrating machinery, and P) Abrasive contamination (sand, dirt).

MEASURE FLOOR DIMENSION, JOINTS, CRACKS, SPALLS, COARSE CONCRETE, AND POPOUTS

In order to estimate coating installation and concrete repair costs, floor dimensions, joints, cracks, spalls, extremely coarse concrete and popouts require measuring. Measure

and record the interior area of all floor surfaces that are to receive coatings. Measure and record the total linear feet of joints and cracks classified by width (Fig. 5, 6). Cracks displaying widths less than 1/16" (dry shrinkage cracks) can be neglected. Measure and record the area of each spall in rectangular repair geometries as illustrated in Fig. 7. Measure and record the total area of concrete surfaces with surface textures greater than \pm 1/4" (concrete areas requiring resurfacing). Measure and record the total area of concrete with popouts greater than 1/4" in diameter (Fig. 8).

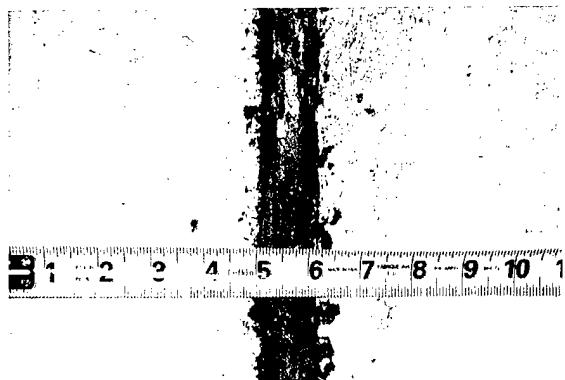


Fig. 5 – Joint.

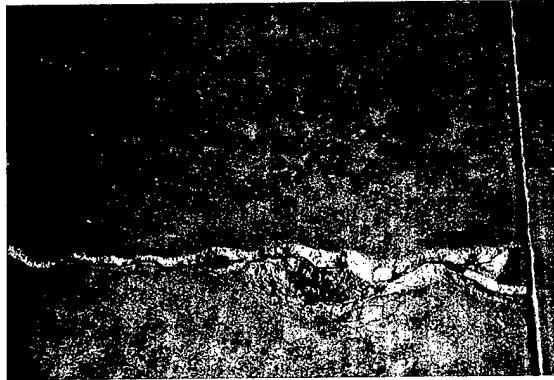


Fig. 6 – Crack.

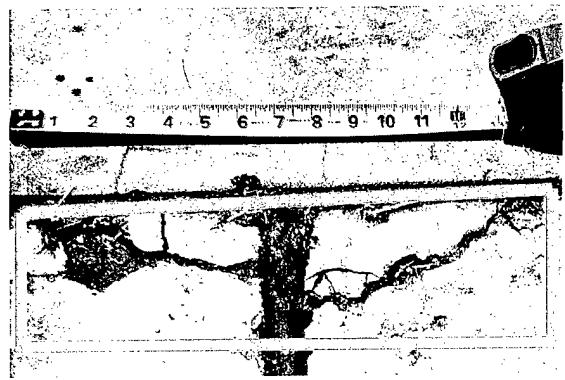


Fig. 7 – Corner spall with repair geometry.

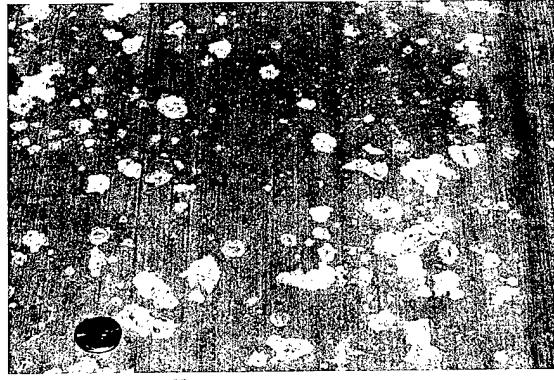


Fig. 8 – Small popouts.

DETERMINE RATE OF MOISTURE VAPOR EMISSION

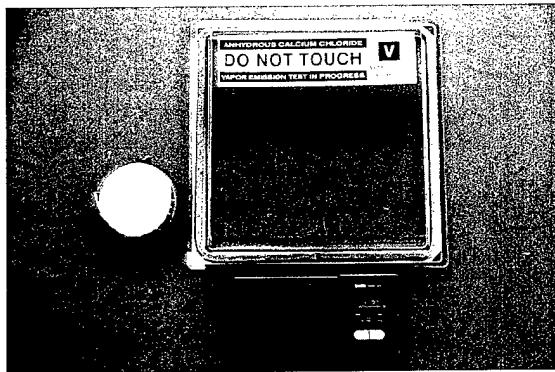


Fig. 9 – Moisture Vapor Emission Test Kit (MVETK) with scale: ASTM-F-1869¹.

When floor coatings are applied to concrete with a high rate of moisture vapor emission, vapor pressure sufficient to lift a coating system may be generated. Quantify the concrete's rate of moisture vapor emission by applying several Moisture Vapor Emission Test Kits (MVETK) and in accordance to ASTM-F-1869¹ (Fig. 9). Remove coatings, tile, and tile adhesive, and apply each kit directly to the concrete for a continuous period of 60 to 72 hours. In general, thin film systems will withstand up to 3.0 lbs moisture/24 hours, 1000 ft² whereas thick film systems will withstand up to 5.0 lbs moisture/24 hours, 1000 ft². If moisture vapor rates are above these values, layered moisture reducing systems are commercially available and are required prior to the application of coatings.

DETERMINE CONCRETE SURFACE STRENGTH

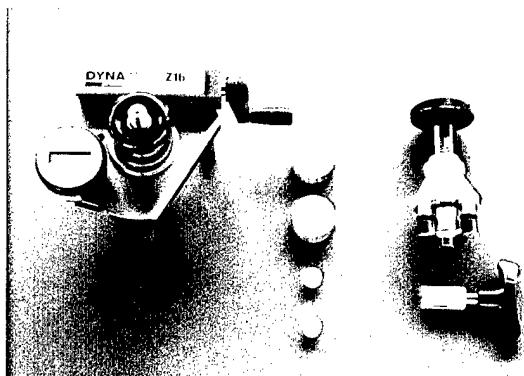


Fig. 10 – Portable adhesion testers with pull-off coupons: L) Dyna tester, R) Elcometer.

To identify concrete with weak surface strength, quantify the concrete's strength using a portable adhesion tester (Fig. 10: ASTM-D-4541 or equivalent¹). For concrete with aggregate larger than 3/8" in diameter, adhesion testers employing 2" diameter pull-off coupons are preferred. Prior to adhering pull-off coupons, the accuracy of testing may be improved by coring a distance of 1/8" to 3/8" into the concrete. If surface strength values are low (≤ 200 psi), concrete surfaces may contain a weak layer of cement paste (laitance). Once the laitance is removed through a surface preparation technique such as shot blasting, surface strength values should increase. If testing does not produce repeated cohesive failures (concrete chunks removed), concrete surfaces may contain surface contamination (fuels, oils, skydrol, fats, waxes, etc.) requiring degreasing prior to re-testing. In general, floors subjected to foot traffic should display a surface strength > 150 psi, whereas floors subjected to either loads or wheel traffic should display a surface strength > 200 psi.

DETERMINE DEPTH OF SURFACE CONTAMINATION

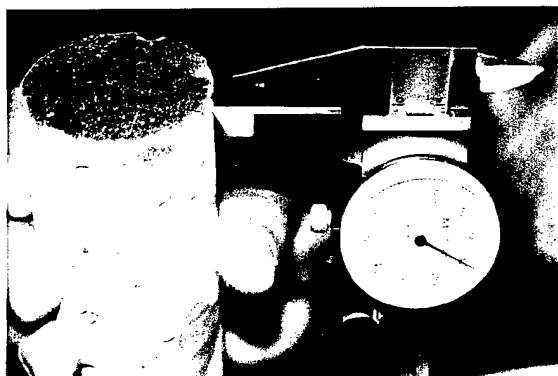


Fig. 11 – Depth of surface contamination.

To quantify the depth of surface contamination and to estimate the degree of surface preparation, extract several concrete cores, preferably from uncoated and visually dirty surfaces. Concrete cores as small as 3/4" (diameter) by 2" (depth) are generally sufficient and resulting holes may be repaired using a cementitious repair mortar. On concrete cores with oil-based contamination (grease, fuels, fats, etc.), a line can usually be seen which separates the dark-colored contamination from the uncontaminated concrete (Fig 11). Measure and report the distance from the surface of each core to the end of the discoloration. Floors with less than a 1/4" depth of surface contamination are easily cleaned and successfully coated. However, floors with greater surface contamination generally require additional cleaning or, in extreme situations, concrete removal and replacement.

DETERMINE ADHESION OF EXISTING COATINGS



Fig. 12 – Coating with spot failing.



Fig. 13 – Elcometer portable adhesion tester with 3/4" pull-off coupon.

If a floor coating displays minor spot failures and has sound adhesion, the coating system may be suitable for spot priming and overcoating (Fig. 12). In several areas, quantify the adhesive strength of the existing coating system using a portable adhesion tester (Fig. 13: ASTM-D-4541 or equivalent¹). Record adhesion values and document the type of coating failure (adhesive or cohesive). When tested for adhesion, in general, coating

systems suitable for overcoating produce either coating adhesive failures above 250 psi or concrete cohesive failures above 200 psi.

If an epoxy coating system was previously applied, then either epoxy or urethane may be installed as an overcoat. Conversely, rigid epoxy coatings have displayed poor performance when employed as an overcoat to flexible urethane topcoats.

SUMMARIZE CONDITION ASSESSMENT RESULTS

Results from a condition assessment may be summarized in the below format: “*Building A contains 12,000 ft² of a failing coating system over concrete with a “Smooth” surface texture. The floor slab has 1200 ft of 1/4” joints, 100 ft of 3/4” joints, 127 ft of cracks up to 3/4” (width), and 50 ft² of spalled concrete. Greater than 12 % of the coating system has spot failed. The coating system has an average adhesive strength of 250 psi whereas the concrete’s surface has an average cohesive strength of 275 psi. Oil contamination has penetrated the concrete’s surface to an average depth of 1/8” (average of three cores). Results from moisture vapor emission testing indicate an average moisture vapor emission rate of 2.0 pounds moisture/24 hours, 1000 ft² (average of 3 tests). The following chemicals are used within the flooring space: A) Jet Fuel (Daily Spills: DS), B) Hydraulic Fluid (Occasional Spills: OS), C) Antifreeze (DS), D) Ethanol (DS), E) Isopropyl Alcohol (DS), F) 10 % Acetone (OS), G) 50 % Sodium Hydroxide (OS), H) 25 % Nitric Acid (OS), and I) 1 % Bleach (DS). The floor is exposed to ambient air temperatures (≈30°F – 100°F), partial sunlight, and receives traffic from heavy forklifts (hard rubber wheels) and light foot traffic.”*

CONCRETE REPAIR, SURFACE PREPARATION, AND COATINGS

Condition assessment results are to be used in specifying appropriate concrete repairs, determining a suitable level of surface preparation, and in selecting a proper coating system. Specifically designed to assist the reader with the above topics, the following trade organizations have videos, publications, and industry standards.

- ACI International²
- The Aberdeen Group³
- The International Concrete Repair Institute (ICRI)⁴
- The Society for Protective Coatings (SSPC)⁵
- NACE International⁶

Furthermore, coating specifications for aircraft maintenance facilities (hangars, shops) are presented in the below Naval Facilities Engineering Service Center publications⁷.

- Special Publication (SP) – 2057 – SHR, “Hangar Floor Coating Specifications: Thin Film, Thick Film, and Overcoating Sound Coating Systems.”
- SP – 2059 – SHR, “Floor Coating Specification for Interior Aircraft Maintenance Shops.”

COATING SELECTION AND EXPECTATIONS

The selection of a coating system generally turns into a balancing act between service life, economics, chemicals/exposures, service conditions, aesthetics, and down time. This task is generally accomplished by numerically ranking each requirement in order of priority and selecting a coating system based on the top requirements. However, optimizing requirements is often replaced with short-term economics. Let's use, for example, the owner of an aircraft maintenance facility with \$3.00 ft² to spend on a flooring system (including joint work). Due to economics, the owner cannot afford a thick film system (> \$5.00 ft²) and is financially limited to a thin film system (degreasing, shot blasting, polysulfide joint sealant, epoxy primer, two coats of urethane with non-skid). Although this is a perfectly acceptable choice, the thick film system's higher initial cost may be justified through increased service life.

Floor coating expectations, as a minimum, should be realistically assessed. Expectations, even in the realm of industrial floors, are typically high and customers are often disappointed with appearance. If the above aircraft maintenance facility required light reflectivity and specified a high gloss white topcoat with a heavy broadcast of non-skid grit, this floor, even if cleaned daily, will trap and show significant levels of dirt. If aesthetics are important, the necessity of frequent cleaning should be taken into consideration to prevent future disappointment.

CONCLUSIONS

A successful floor coating installation always starts with a concrete condition assessment. Once adopted, this practice will enable coating inspectors to identify problem floors and permit specifiers to recommend coating solutions rather than costly re-work.

ACKNOWLEDGEMENTS

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1. American Society for Testing and Materials (ASTM). West Conshohocken, PA.
2. www.aci-int.org
3. www.wocnet.com
4. www.icri.org
5. www.sspc.org
6. www.nace.org
7. Please contact Mr. C. Dave Gaughen for a copy of the specifications at (805) 982 – 1065.